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National Semiconductor

June 1989

DM74184/DM74185A BCD-to-Binary and Binary-to-BCD Converters

General Description

These monolithic converters are derived from the 256-bit read only memories, DM5488, and DM7488. Emitter connections are made to provide direct read-out of converted codes at outputs Y8 through Y1, as shown in the function tables. These converters demonstrate the versatility of a read only memory in that an unlimited number of reference tables or conversion tables may be built into a system. Both of these converters comprehend that the least significant bits (LSB) of the binary and BCD codes are logically equal, and in each case the LSB bypasses the converter as illustrated in the typical applications. This means that a 6-bit converter is produced in each case. Both devices are cascadable to N bits.

An overriding enable input is provided on each converter which when taken high inhibits the function, causing all outputs to go high. For this reason, and to minimize power consumption, unused outputs Y7 and Y8 of the 185A and all "don't care" conditions of the 184 are programmed high. The outputs are of the open-collector type.

DM74184 BCD-TO-BINARY CONVERTERS

The 6-bit BCD-to-binary function of the DM74184 is analogous to the algorithm:

a. Shift BCD number right one bit and examine each decade. Subtract three from each 4-bit decade containing a binary value greater than seven.

b. Shift right, examine, and correct after each shift until the least significant decade contains a number smaller than eight and all other converted decades contain zeros.

In addition to BCD-to-binary conversion, the DM74184 is programmed to generate BCD 9's complement or BCD 10's complement. Again, in each case, one bit of the complement code is logically equal to one of the BCD bits; therefore, these complements can be produced on three lines. As outputs Y6, Y7 and Y8 are not required in the BCD-to-binary conversion, they are utilized to provide these complement codes as specified in the function table when the devices are connected as shown.

DM74185A BINARY-TO-BCD CONVERTERS

The function performed by these 6-bit binary-to-BCD converters is analogous to the algorithm:

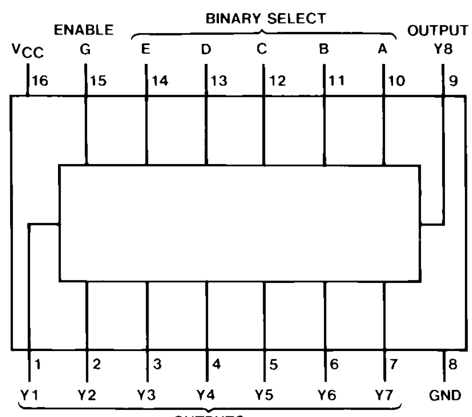
a. Examine the three most significant bits. If the sum is greater than four, add three and shift left one bit.

b. Examine each BCD decade. If the sum is greater than four, add three and shift left one bit.

c. Repeat step b until the least-significant binary bit is in the least-significant BCD location.

(Continued)

Connection Diagram



TL/F/6561–1

Order Number DM74184N or DM74185AN
See NS Package Number N16E

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Absolute Maximum Ratings (Note)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage	7V
Input Voltage	5.5V
Output Voltage	7V
Operating Free Air Temperature Range	0°C to +70°C
Storage Temperature Range	−65°C to +150°C

Note: *The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the "Electrical Characteristics" table are not guaranteed at the absolute maximum ratings. The "Recommended Operating Conditions" table will define the conditions for actual device operation.*

Recommended Operating Conditions

Symbol	Parameter	Min	Nom	Max	Units
V_{CC}	Supply Voltage	4.75	5	5.25	V
V_{IH}	High Level Input Voltage	2			V
V_{IL}	Low Level Input Voltage			0.8	V
V_{OH}	High Level Output Voltage			5.5	V
I_{OL}	Low Level Output Current			12	mA
T_A	Free Air Operating Temperature	0		70	°C

'184 and '185A Electrical Characteristics

over recommended operating free air temperature range (unless otherwise noted)

Symbol	Parameter	Conditions	Min	Typ (Note 1)	Max	Units
V_I	Input Clamp Voltage	V_{CC} = Min, I_I = −12 mA			−1.5	V
I_{CEX}	High Level Output Current	V_{CC} = Min, V_O = 5.5V V_{IL} = Max, V_{IH} = Min			100	μA
V_{OL}	Low Level Output Voltage	V_{CC} = Min, I_{OL} = Max V_{IH} = Min, V_{IL} = Max			0.4	V
I_I	Input Current @ Max Input Voltage	V_{CC} = Max, V_I = 5.5V			1	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V			25	μA
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V			−1	mA
I_{CCH}	Supply Current with Outputs High	V_{CC} = Max		65	95	mA
I_{CCL}	Supply Current with Outputs Low	V_{CC} = Max		80	99	mA

'184 and '185A Switching Characteristics

at V_{CC} = 5V and T_A = 25°C (See Section 1 for Test Waveforms and Output Load)

Symbol	Parameter	From (Input) To (Output)	R_{L1} = 400Ω, R_{L2} = 600Ω, C_L = 15 pF (See Test Circuit)		Units
			Min	Max	
t_{PLH}	Propagation Delay Time Low to High Level Output	Enable G to Output		35	ns
t_{PHL}	Propagation Delay Time High to Low Level Output	Enable G to Output		35	ns
t_{PLH}	Propagation Delay Time Low to High Level Output	Binary Select to Output		35	ns
t_{PHL}	Propagation Delay Time High to Low Level Output	Binary Select to Output		35	ns

Note 1: All typicals are at V_{CC} = 5V, T_A = 25°C.

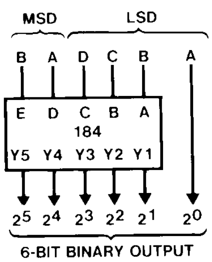
General Description (Continued)

DM74184 BCD-to-Binary

TABLE I. Package Count and Delay Times for BCD-to-Binary Conversion

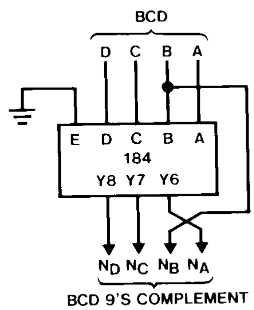
Input (Decades)	Packages Required	Total Delay Times (ns)	
		Typ	Max
2	2	56	80
3	6	140	200
4	12	196	280
5	19	280	400
6	28	364	520

6-Bit Converter



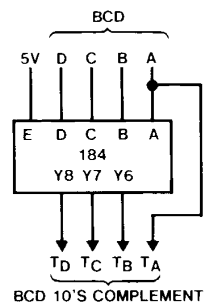
TL/F/6561–2

BCD 9's Complement Converter



TL/F/6561–3

BCD's 10's Complement Converter



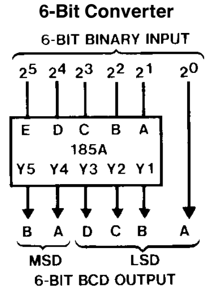
TL/F/6561–4

DM74185A Binary-to-BCD

TABLE II. Package Count and Delay Times for Binary-to-BCD Conversion

Input (Bits)	Packages Required	Total Delay Times (ns)	
		Typ	Max
4 to 6	1	25	40
7 or 8	3	50	80
9	4	75	120
10	6	100	160
11	7	125	200
12	8	125	200
13	10	150	240
14	12	175	280
15	14	175	280
16	16	200	320
17	19	225	360
18	21	225	360
19	24	250	400
20	27	275	440

6-Bit Converter



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Function Tables

Binary Words		Inputs						Outputs							
		Binary Select					Enable								
		E	D	C	B	A	G	Y8	Y7	Y6	Y5	Y4	Y3	Y2	Y1
0	1	L	L	L	L	L	L	H	H	L	L	L	L	L	L
2	3	L	L	L	L	H	L	H	H	L	L	L	L	L	H
4	5	L	L	L	H	L	L	H	H	L	L	L	L	H	L
6	7	L	L	L	H	H	L	H	H	L	L	L	L	H	H
8	9	L	L	H	L	L	L	H	H	L	L	L	H	L	L
10	11	L	L	H	L	H	L	H	H	L	L	H	L	L	L
12	13	L	L	H	H	L	L	H	H	L	L	H	L	L	H
14	15	L	L	H	H	H	L	H	H	L	L	H	L	H	L
16	17	L	H	L	L	L	L	H	H	L	L	H	L	H	H
18	19	L	H	L	L	H	L	H	H	L	L	H	H	L	L
20	21	L	H	L	H	L	L	H	H	L	H	L	L	L	L
22	23	L	H	L	H	H	L	H	H	L	H	L	L	L	H
24	25	L	H	H	L	L	L	H	H	L	H	L	L	H	L
26	27	L	H	H	L	H	L	H	H	L	H	L	L	H	H
28	29	L	H	H	H	L	L	H	H	L	H	L	H	L	L
30	31	L	H	H	H	H	L	H	H	L	H	H	L	L	L
32	33	H	L	L	L	L	L	H	H	L	H	H	L	L	H
34	35	H	L	L	L	H	L	H	H	L	H	H	L	H	L
36	37	H	L	L	H	L	L	H	H	L	H	H	L	H	H
38	39	H	L	L	H	H	L	H	H	L	H	H	H	L	L
40	41	H	L	H	L	L	L	H	H	H	L	L	L	L	L
42	43	H	L	H	L	H	L	H	H	H	L	L	L	L	H
44	45	H	L	H	H	L	L	H	H	H	L	L	L	H	L
46	47	H	L	H	H	H	L	H	H	H	L	L	L	H	H
48	49	H	H	L	L	L	L	H	H	H	L	L	H	L	L
50	51	H	H	L	L	H	L	H	H	H	L	H	L	L	L
52	53	H	H	L	H	L	L	H	H	H	L	H	L	L	H
54	55	H	H	L	H	H	L	H	H	H	L	H	L	H	L
56	57	H	H	H	L	L	L	H	H	H	L	H	L	H	H
58	59	H	H	H	L	H	L	H	H	H	L	H	H	L	L
60	61	H	H	H	H	L	L	H	H	H	H	L	L	L	L
62	63	H	H	H	H	H	L	H	H	H	H	L	L	L	H
All		X	X	X	X	X	H	H	H	H	H	H	H	H	H

Function Tables (Continued)

BCD-to-Binary Converter

BCD Words		Inputs (See Note A)						Outputs (See Note B)				
		E	D	C	B	A	G	Y5	Y4	Y3	Y2	Y1
0	1	L	L	L	L	L	L	L	L	L	L	L
2	3	L	L	L	L	H	L	L	L	L	L	H
4	5	L	L	L	H	L	L	L	L	L	H	L
6	7	L	L	L	H	H	L	L	L	L	H	H
8	9	L	L	H	L	L	L	L	L	H	L	L
10	11	L	H	L	L	L	L	L	L	H	L	H
12	13	L	H	L	L	H	L	L	L	H	H	L
14	15	L	H	L	H	L	L	L	L	H	H	H
16	17	L	H	L	H	H	L	L	H	L	L	L
18	19	L	H	H	L	L	L	L	H	L	L	H
20	21	H	L	L	L	L	L	L	H	L	H	L
22	23	H	L	L	L	H	L	L	H	L	H	H
24	25	H	L	L	H	L	L	L	H	H	L	L
26	27	H	L	L	H	H	L	L	H	H	L	H
28	29	H	L	H	L	L	L	L	H	H	H	L
30	31	H	H	L	L	L	L	L	H	H	H	H
32	33	H	H	L	L	H	L	H	L	L	L	L
34	35	H	H	L	H	L	L	H	L	L	L	H
36	37	H	H	L	H	H	L	H	L	L	H	L
38	39	H	H	H	L	L	L	H	L	L	H	H
Any		X	X	X	X	X	H	H	H	H	H	H

BCD 9's or BCD 10's Complement Converter

BCD Word	Inputs (See Note C)						Outputs (See Note D)		
	E†	D	C	B	A	G	Y8	Y7	Y6
0	L	L	L	L	L	L	H	L	H
1	L	L	L	L	H	L	H	L	L
2	L	L	L	H	L	L	L	H	H
3	L	L	L	H	H	L	L	H	L
4	L	L	H	L	L	L	L	H	H
5	L	L	H	L	H	L	L	H	L
6	L	L	H	H	L	L	L	L	H
7	L	L	H	H	H	L	L	L	L
8	L	H	L	L	L	L	L	L	H
9	L	H	L	L	H	L	L	L	L
0	H	L	L	L	L	L	L	L	L
1	H	L	L	L	H	L	H	L	L
2	H	L	L	H	L	L	H	L	L
3	H	L	L	H	H	L	L	H	H
4	H	L	H	L	L	L	L	H	H
5	H	L	H	L	H	L	L	H	L
6	H	L	H	H	L	L	L	H	L
7	H	L	H	H	H	L	L	L	H
8	H	H	L	L	L	L	L	L	H
9	H	H	L	L	H	L	L	L	L
Any	X	X	X	X	X	H	H	H	H

H = High Level, L = Low Level, X = Don't Care

Note A: Input Conditions other than those shown produce highs at outputs Y1 through Y5.

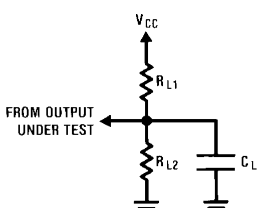
Note B: Output Y6, Y7, and Y8 are not used for BCD-to-Binary conversion.

Note C: Input conditions other than those shown produce highs at outputs Y6, Y7, and Y8.

Note D: Outputs Y1 through Y5 are not used for BCD 9's or BCD 10's complement conversion.

†When these devices are used as complement converters, input E is used as a mode control. With this input low, the BCD 9's complement is generated; when it is high, the BCD 10's complement is generated.

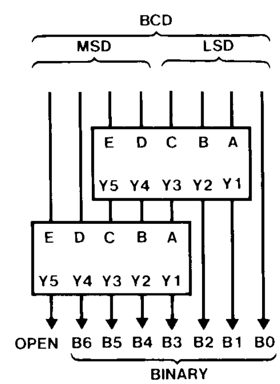
Test Circuit



TL/F/6561–6

C_L includes probe and jig capacitance

Typical Applications

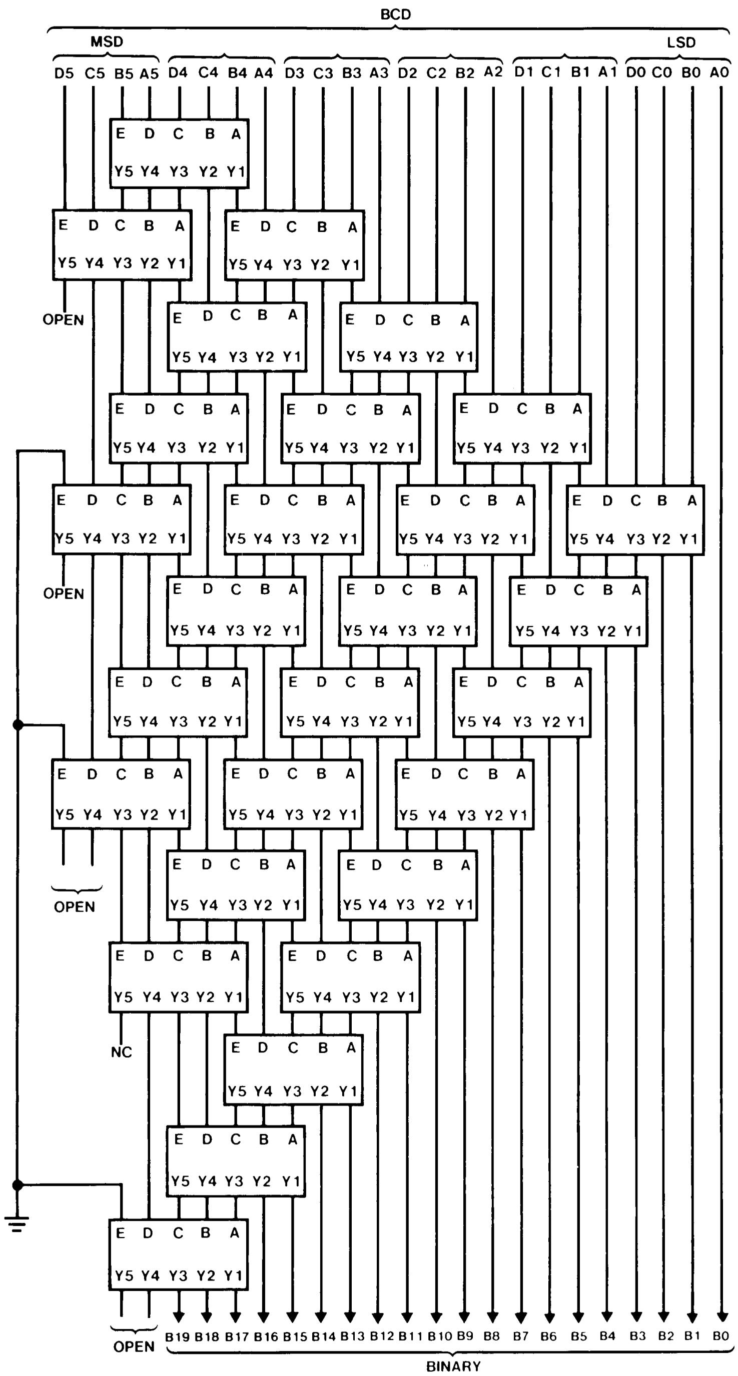


TL/F/6561–7

FIGURE 1. BCD-to-Binary Converter for Two BCD Decades

MSD—Most significant decade
LSD—Least significant decade
Each rectangle represents a DM74184

Typical Applications (Continued)

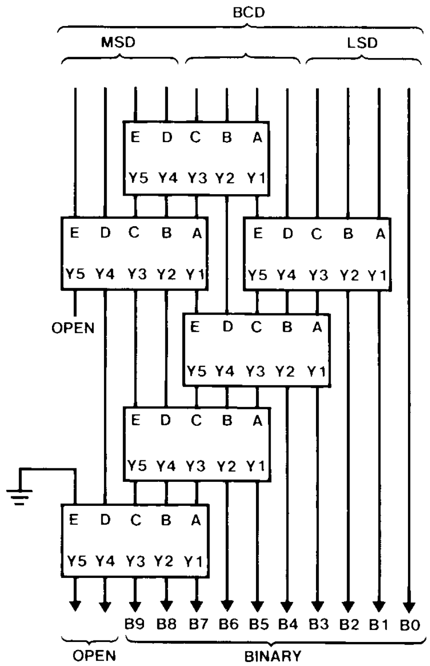


TL/F/6561–9

FIGURE 2. BCD-to-Binary Converter for Six BCD Decades

MSD—Most significant decade
LSD—Least significant decade
Each rectangle represents a DM74184

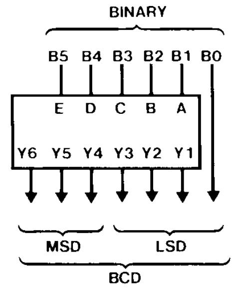
Typical Applications (Continued)



TL/F/6561–8

FIGURE 3. BCD-to-Binary Converter for Three BCD Decades

MSD—Most significant decade
LSD—Least significant decade
Each rectangle represents a DM74184



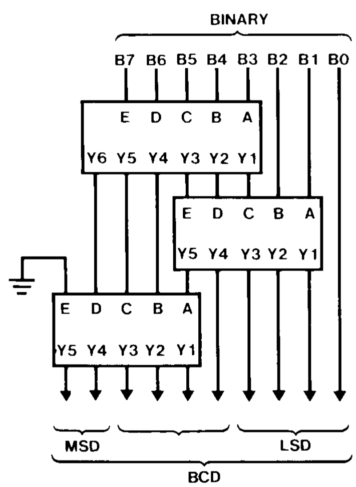
TL/F/6561–10

FIGURE 4. 6-Bit Binary-to-BCD Converter

MSD—Most significant decade
LSD—Least significant decade

Note A: Each rectangle represents a DM74185A.

Note B: All unused E inputs are grounded.



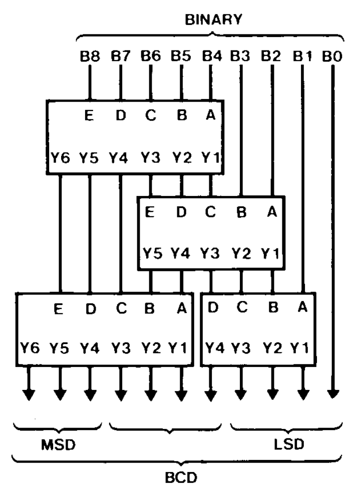
TL/F/6561–11

FIGURE 5. 8-Bit Binary-to-BCD Converter

MSD—Most significant decade
LSD—Least significant decade

Note A: Each rectangle represents a DM74185A.

Note B: All unused E inputs are grounded.



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FIGURE 6. 9-Bit Binary-to-BCD Converter

MSD—Most significant decade
LSD—Least significant decade

Note A: Each rectangle represents a DM74185A.

Note B: All unused E inputs are grounded.

Typical Applications (Continued)

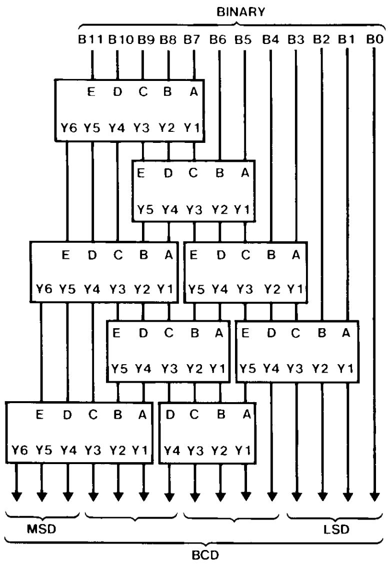


FIGURE 7. 12-Bit Binary-to-BCD Converter (See Note B)

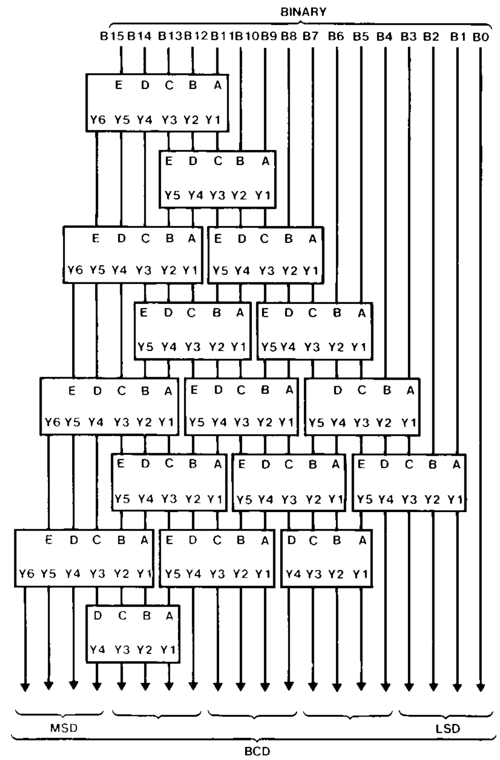


FIGURE 8. 16-Bit Binary-to-BCD Converter (See Note B)

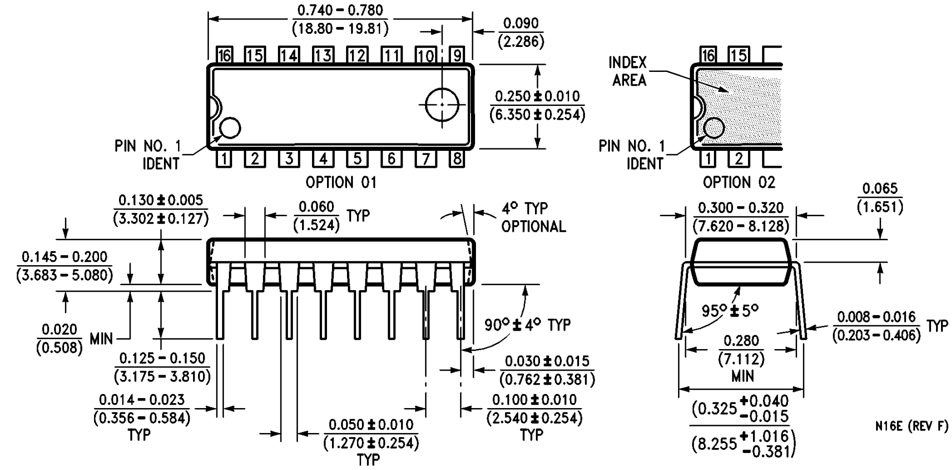
MSD—Most significant decade

LSD—Least significant decade

Note A: Each rectangle represents a DM74185A.

Note B: All unused E inputs are grounded.

Physical Dimensions inches (millimeters)



16-Lead Molded Dual-In-Line Package (N)
Order Number DM74184N or DM74185AN
NS Package Number N16E

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